SYNGAS QUALITY IN GASIFICATION OF HIGH MOISTURE MUNICIPAL SOLID WASTES

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Introduction

With widespread environmental concerns among non-technical people around the conventional incinerators in city areas, it becomes more and more difficult to get permission for new municipal solid wastes (MSW) treatment facilities in Korea like many other countries. Although dioxins are not a problem anymore technically because of the added SCR facility in reducing dioxins below the environmental regulations of 0.1 ng/Nm^3, residents in Korea still remain skeptical and start to insist that advanced technologies should be employed in order to build a new MSW treatment facility in their backyard. Germany and Japan are in the front of building MSW plants applying advanced technologies like pyrolysis, gasification, and melting. In applying the advanced technologies into Korean MSW that has unique features in composition like high moisture content due to waste vegetables, which in turn result in low heating value of MSW, there are great demand in proving the technology with actual Korean MSW before introducing major scale plants of 150-600 ton/day size.

During the last few years, newly enforced waste separation policy in major cities in Korea yielded an increased heating value of MSW as high as 3,000 kcal/kg. Since small cities are still in lag behind of following wastes separation policy, gasification plants in Korea should have a room to treat the low heating value waste quality at least for the introductory plants. Following the ever-increasing heating value in MSW that can be recovered as an alternative energy source, it appears that installing advanced MSW technology plants are inevitable in Korea in the next few years. In this paper, current research status of gasification using MSW of high moisture content is discussed.

Gasification Facility

Figure 1 shows the 3-D view of 2.5 ton/day-class gasification facility that was being developed for the municipal solid wastes. Maximum pressure and temperature for the operation are 1 bar and 1550^{o}C, respectively.

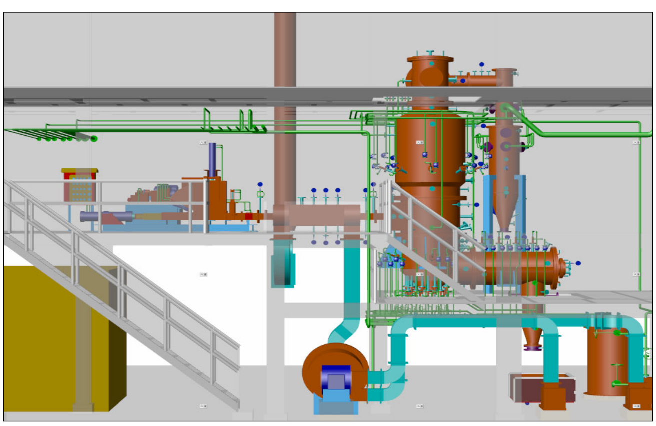

Figure 1. 3-D design view of the 2.5 ton/day MSW gasification system.

Plant consists of feed accepting apparatus, MSW compacting section, partial pyrolysis section, gasification/melting reactor part, slag homogenizing section, and quick syngas quenching section. Feed is introduced into the plant as 20 liters vinyl bags that are one way to discard MSW in Korean cities, after which MSW vinyl bags are compressed and pushed into the partial pyrolysis section in that few centimeters of surface parts are carbonized. During the compressing operation, about 10-30% of the moisture in MSW are extracted. Extracts are scavenged and pumped into the end section of the partial pyrolyzing section. Main gasification section works with LPG burners located at the bottom part of the reactor. Molten slag flows into the slag homogenizer that works to ensure the melting of all inorganic components and finally drops into the water-quenching chamber to produce slag. Gasifier temperature is maintained typically in 1,200-1,450^{o}C range while the slag homogenizer in 1,400-1,550^{o}C.

Figure 2 exhibits key components of the plant (Left: gasifier section, Right: slag homogenizer). Gasifier contains two layers of refractories with water cooling pipes and jackets around the main gasification area. Pure oxygen is provided after vaporizing and compressing from liquefied oxygen storage tanks.

High moisture-containing MSW from Y-City in Korea has an average high heating value of 2,176 kcal/kg (as-received basis) with 55.8% moisture and 6.9% ash. Components of MSW in weight were 46.8% kitchen food wastes, 27.1% paper, 5.9% textiles, 11.1% vinyls, 2.3% plastics, 6.9% glass and porcelain. Another tested MSW of medium moisture from K-City in Korea contains 50.4% moisture, and 5.5% ash with HHV of 2,686 kcal/kg. Components of K-City MSW consist of 29.6% kitchen food wastes, 33.7% paper, 9.7% textiles, 19.5% vinyls, 5.6% plastics, 1.9% foam materials.

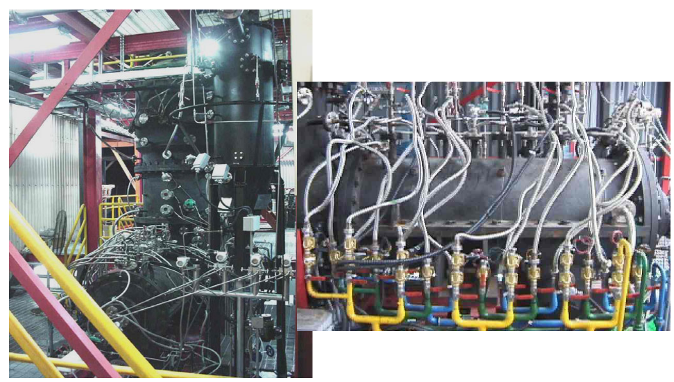

Figure 2. Gasification section (left) and the slag homogenizing section (right) of the pilot gasification facility.

Results and Discussion

Gasification results for the 55.8% moisture-containing MSW are illustrated in **Figure 3**. Syngas composition shows CO 25-30%, 20-35% hydrogen, and 22-40% CO_2.

Figure 4 demonstrates typical waste compositions and produced syngas quality from similar types of gasification plants of Italy, Japan, and Germany. Korean MSW contains highest moisture content followed by Japanese MSW near 50%. MSW from European countries exhibits less than 30% moisture, but much higher inorganic composition of reaching 25% compared to less than 8% in Korea and Japan. As expected, high moisture containing MSW yielded lower CO/H_2 and higher CO_2 contents, which result in lower heating value in syngas. Gasification of Korean MSW produces a syngas of typical 26-28% CO and hydrogen composition with a HHV 1,640 kcal/Nm^3. In this case, cold gas efficiency based upon HHV was 53%.

Figure 5 shows gasification results for the 50.4% moisture-containing Korean MWS from the K-City where most of food wastes are separated and reusable materials are recycled. Most of moisture originated from soaked rain during storage in K-City.

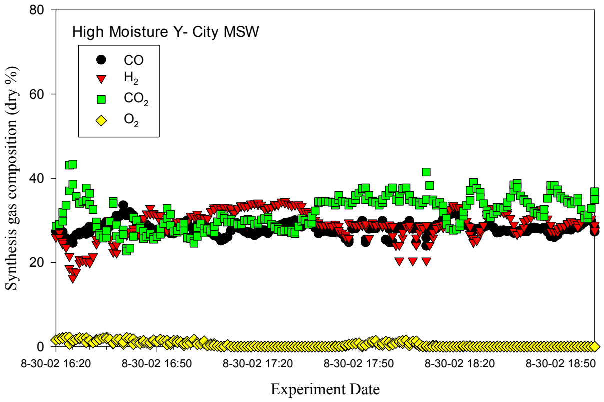

Figure 3. Syngas compositions from gasification of 55.8% moisture MSW from Y-City in Korea.

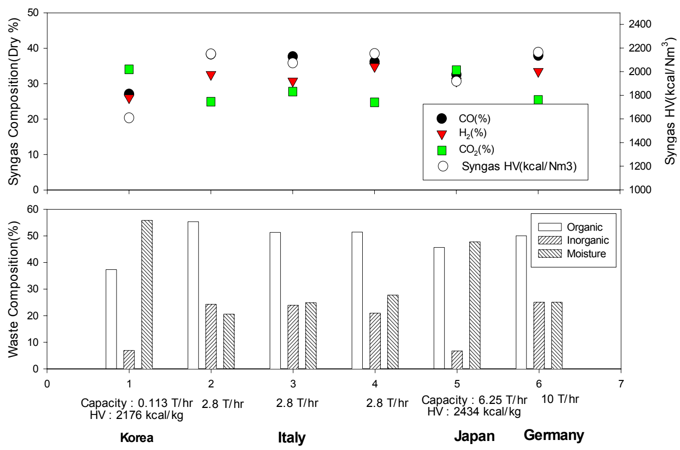

Figure 4. Comparison of syngas composition and heating value by similar types of gasification for MSW from several countries.

Moreover, the MSW in K-City contains more papers and less kitchen wastes than Y-City MSW and thus providing more organics feed for gasification at the same weight basis. Resulting syngas composition demonstrates a higher heating value in syngas as 2,125 kcal/Nm^3 with 38% CO and 32% hydrogen contents. Energy content in syngas from K-City MSW is almost as high as heating value from coal gasification. Therefore, with appropriate cleanup steps, the produced syngas can be utilized as a good alternative energy source.

Slags produced from high moisture Y-City MSW are shown in **Figure 6** in that few mm of round and sharp-edged shapes are illustrated.

To utilize slags for construction materials, they should fulfill the requirements in environmental leaching regulation. **Table 1** demonstrates that produced slags are environmentally safe in leaching tests. Please note that Korean leaching regulations are about ten times less stringent than in Japan and other developed countries. The results in Table 1 exhibit that even more stringent regulations can be met through the gasification/melting process.

Conclusions

Experience in coal gasification during the last ten years has been successfully applied for the MSW gasification/melting pilot plant. Gasification for Korean MSW of high moisture content yielded a syngas comprising of 22-40% CO and 25-38% hydrogen with a heating value equivalent of syngas from coal gasification. Since energy grade in MSW would increase above 3,000 kcal/kg in major cities, advanced gasification/melting process for MSW appears to be an inevitable choice in Korea based upon the option of producing clean energy without polluting environment as well as the people's wish for advanced technology that ensures less pollutants in their backyard.

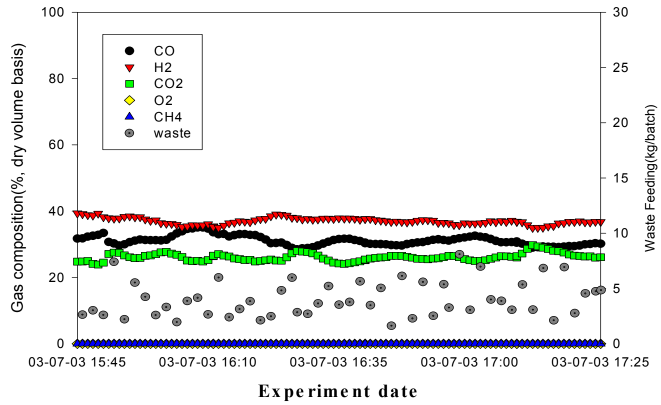

Figure 5. Syngas compositions from gasification of 50.4% moisture MSW from K-City in Korea.

Figure 6. Produced slags by gasification/melting from high moisture Y-City MSW (unit: cm).

Table 1. Leaching Test Results for Slags from Y-City MSW

Item	Unit	Result	Korean Environmental Standards
Total Hg	mg/l	n.d.	0.005
Cd	mg/l	n.d.	0.3
Pb	mg/l	0.03	3.0
Cr^{+6}	mg/l	n.d.	1.5
As	mg/l	n.d.	1.5
Se	mg/l	n.d.	-
Tota CN	mg/l	n.d.	1.0
Organo-phosphrous	mg/l	n.d.	1.0
Alkyl-mercury	mg/l	n.d.	-
PCB	mg/l	n.d.	-
Trichloroethylene	mg/l	n.d.	0.3
Tetrachloroethylene	mg/l	n.d.	0.1

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